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The Threat to Man from Contamination of the Water Environment

by

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Because it is constantly circulating in nature, water *193
is the factor which connects all the elements of the geographical environment into a unified complex most closely. It is the element in man's environment to which the human organism is most constantly and closely bound. The mineral composition of water, and its various biological and chemical impurities are an indicator, among other things, of the nature and intensity of the changes taking place in man's environment. At the same time, as one of man's trophic

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* The figures in the right-hand margin indicate page numbers in the original (Tr.).

links, water can affect the biochemical composition of the human body, and influence its various biochemical reactions.

Among other things, the micro and macroelements contained in water control the metabolic functions of the human body, and preserve the physical and chemical integrity of the body's cells and tissues by maintaining their proper bioelectric potentials. Hence several elements have acquired the label "body bioelements." It is apparent that any excess or deficiency of these elements will have an unfavourable effect on human health by directly or indirectly causing certain types of disease conditions.

Also important from the point of view of human health is any kind of contamination of water, i.e. the appearance of any new and unexpected (in terms of biological norms) chemical substances of a non-inert nature, or of substances which are often actually toxic to various tissues which may come into direct contact with, and be directly affected by them.

The present paper presents important information from the literature, along with the author's own observations in this field. The author concludes that the present-day tendency towards an increase in the incidence of certain diseases, especially cardiovascular and neoplastic diseases (including leukemias, among other things), may be an expression not only of changes in the mineral composition of water (e.g. magnesium (Mg), selenium (Se), iron (Fe) deficiences,

etc.), but also the effect of unfavourable influences on the body of various chemical substances in water (e.g. pesticides, nitrosoamines, or "aflatoxins" - metabolites of imperfect fungi) - especially in drinking water.

Hence those responsible for the water consumed by people should be aware of the fact that any changes in its mineral composition (in other words, its mineral degradation), or any contamination with chemical substances which affect the human body may directly, indirectly or synergetically cause specific changes within the body, and may be responsible for the growing incidence of certain "diseases of modern civilization." The final section of the paper 194
contains a number of sanitary and medical requisites concerning drinking water which arise as a result of the preceding discussion.

Water is that element of the geographical environment which, by constantly circulating within nature, changes its location. Depending on the permeability of the soil, a certain portion of it sinks (as we know) into the ground, dissolving and distributing various mineral substances in the process. Because of its ability to move about, water connects all the elements of the geographic environment into a unified complex most closely [12].

At the same time, water is that element of man's natural environment to which the human body is most

constantly and closely bound. Thus the mineral composition of water is determined on the one hand by natural erosional forces which are independent of man, and on the other by the activity of man himself (for example, through mineral fertilization of the soil).

The result (often unintentional) of man's agricultural and industrial activities is very often the direct or indirect contamination of surface, subsurface and ground water with various chemical substances such as pesticides, detergents, various industrial waste products, etc.

Thus the water collected by man for economic and consumption purposes, its mineral composition, and its various biological and chemical impurities are an indicator of the nature and intensity of the changes taking place in his environment. As one of man's trophic links, water directly or indirectly determines the biochemical composition of his body, shapes his internal environment, and affects various biochemical reactions.

It is also apparent that the mineral composition of the body, its content of micro and macroelements, and the biochemical reactions occurring not only in the human body but also in other vertebrates, are affected by hormonal activity within the organism in question; among other things, hormonal activity also regulates the levels, and not just the assimilibility, of the various elements (including those in body fluids). Thus hormonal activity plays an

important role in the mineral economy of the body: in the dissolution and transport of the various substances in the body, and in the formation of their levels [3]. The importance of water to the human organism can be grasped more readily if we add that, on the average, the total quantity of all human body fluids accounts for 60% of body weight [3]. It is for these reasons then that the physical and chemical properties of water, and in particular its mineral composition. its biological purity, and the presence (or rather absence) of contaminants, are so important for human health.

It will be easier to understand how mineral components act, and how ecological factors affect many diseases 195
if we realize that although micro and macroelements do not act as energy suppliers for the body, they nevertheless control the body's metabolic functions, and preserve the physical and chemical integrity of its cells and tissues by maintaining proper bioelectric potentials.

Since several of the elements have acquired the label body "bioelements" because of their role in essential biochemical processes, it would seem apparent that their excess or deficiency must have an unfavourable effect on human health.

As a component of man's natural environment and one of his basic trophic links, water shapes the mineral and biochemical composition of the internal environment of the

human body in a fundamental way either directly as drinking water, or indirectly through agricultural food products. Thus from the point of view of the threat to human health, any degradation, or disturbance (disintegration), of the biologically normal mineral composition of the water consumed by humans and animals (which consitute, among other things, a potential source of food for man) is very important. Also significant from the point of view of human health is any kind of contamination, or the appearance of new and unexpected (in terms of biological norms) chemical substances of a non-inert nature, or of substances which may often even be toxic in the short or long term, or have a toxic cummulative effect.

According to well-known "inorganic chemist" D. R. Williams, the elements H, C, N, O, Na, Mg, K, Ca, P, S, Cl, Mo, Mn, Fe, Co, Cu, Zn and J are regarded as essential for health, and the elements Si, V, Cr, Se, Br, Sn and F as useful to the body [15, 16]. Hence any disturbance in the levels and mutual proportions of these 25 most important "bio-elements" (for example, as a result of the "degradation" mentioned above) will be reflected in the biochemistry of the body, and may directly or indirectly cause certain disease conditions.

In order to illustrate this view, several pertinent observations are presented below. Berg and Burbank have determined that cancer of the oral cavity and intestines

occurred more frequently in environments in which water contained higher concentrations of nickel; where there was a greater concentration of arsenic, a higher incidence of granulocytic leukemia and cancer of the larynx and eyeball was found [2]. According to these same authors, beryl occurred in significantly higher concentrations in areas where the incidence of bone, breast and uterine cancer was high; leukemias, lymphosarcomas and cancers of the kidney, stomach and varies occurred more frequently in regions where the water had a higher concentration of lead [2].

Among the very important metals which are essential to life is magnesium. The content of this element in the 196 human body (like most of the other bioelements) is determined by its level in the natural environment. The level of magnesium in the soil and water environment determines its quantities in both plant and animal food products, and hence, ultimately, also in the human body. The level of magnesium in the natural environment differs from region to region depending on the nature and type of soil, the agricultural methods used, and the intensity and type of soil fertilization. Magnesium is directly or indirectly involved in over 40 different enzymatic reactions in the human body. In addition, it also functions as a "stabilizer" for the human chromosomal system, and consequently affects the body's resistance to the mutational effects of ionizing radiation and various harmful chemical substances. Magnesium

deficiency causes changes in nerve conductivity, lowers the presynaptic sensitivity threshold, and activates the body's stress alert system (including bioclimatic stresses). In the light of the results presented at the Vittel congress of May 9 to 15, 1971, it is generally recognized that the magnesium ion plays a specific role in the body's defence processes as the above-mentioned anti-stress and ionizing radiation-protection agent, and also as an anti-toxic, anti-allergic, anti-anaphylactic and anti-inflammatory agent [1]. During the above-mentioned congress, devoted to diseases caused by magnesium deficiency, Prof. Durlach stated: "A characteristic trait of the modern civilized world is the steadily diminishing level of the Mg ion." Diseases of civilization caused by magnesium deficiency in the body seem to be determined by deficiencies in the various links in the food chain. Intensive fertilization of the soil, especially with mineral potassic fertilizers, promotes the displacement of the magnesium ion by the potassium ion, and the intensive leaching of magnesium from the soil environment; as a consequence, the flow of magnesium into larger water reservoirs increases. In the same way, the increasing acidity of the soil, symptomized by increased potassium levels, leads to the "impoverishment" (in terms of magnesium) of the soil environment, drinking water, and agricultural products, which ultimately results in a reduction of the Mg level in the human population, with all its unfavourable (from the point of view of human health) consequences.

A deficiency of Fe in water (which, as we know, is essential for the synthesis of hemoglobin and myoglobin) can result in reduced hemoglobin levels, hypochronic anemia, and defective saturation of the muscles with myoglobin [1]. An iodine deficiency, on the other hand, causes defects in the synthesis of thyroxine and triiodothyronine [1]. Kobayashi [10] has determined that there is a close link among Japanese between the acidity of drinking water and extravasation of blood into the central nervous system. Shroeder gave a more precise description of this probable causal link on the 197
basis of his own observations. He states that the softer and more acidic the drinking water, the greater the death rate from atheromatous diseases [1]. At the same time, many authors link arterial hypertension with an excess of cadmium in the drinking water, and hypertrophic cardiomyopathy with an increase in the consumption of beer, to which (as is well known) cobalt is added to promote foaming. Januszko et al. have shown that in endemic areas of Bialystok Province there is a strong correlation ($r = +0.93$) between the morbidity rate of goitre, and the combined concentration of J, Ca and Mg in the drinking water [7]. On the basis of statistical elimination, these authors revealed that the strongest relationship involved magnesium ($r = +0.71$), which suggests the hypothesis (in need of verification) that magnesium may be an important factor in the occurrence of goitre.

The present author's own studies have revealed a statistically significant, positive, simple linear correlation ($r = +0.733$) between the morbidity rate of leukemia among people living in rural areas of the Cracow region, and the percentage of the population using well water (most likely either degraded, in terms of mineral composition, or contaminated); the same correlation coefficient was barely above zero for populations using water from natural sources. A negative simple linear correlation ($r = -0.737$), however, was found for populations using the community water system, i.e. drinking water under the strictest sanitary control [6].

The contamination of water with pesticides most likely also affects human health [5]. The author's own epidemiological studies into the environmental factors influencing the incidence of leukemias among humans between 1961 and 1968 revealed, among other things, that there is a positive, statistically significant, simple linear correlation ($r = +0.637$) between the leukemia morbidity rate among people living in rural areas in the Cracow region, and the use of seed dressings, whose predominant active agent during that period, as is well known, were mercury compounds. This hypothesis regarding the probable role of mercury in causing proliferations of the hematopoietic system is further supported by statistically significant evidence of higher mercury levels in individuals suffering from leukemia as

compared to healthy individuals from the same family and a randomly selected control group. This is indirect proof that recent increases in the level of mercury contamination of the water and soil environments affects the human body and may be a cause of various proliferative diseases of the hematopoietic system [5].

A statistically significant, positive, simple linear correlation has also been found [6] between the morbidity rate of peracute leukemias among people living in rural areas of the Cracow region, and the use of chemical herbicides ($r = +0.655$) and sprayed chemical pesticides ($r = +0.630$) in those areas. These epidemiological and mathematical observations of the author, which demonstrate a significant correlation between the morbidity rate of leukemia, and the use of certain pesticide groups, are objectively supported by a relatively large number of other studies [4, 8, 13]. 198

Thus for example, in 1958 Jadlicka et al. described a case of paramyeloblastic leukemia in two related individuals which occurred following probable contact with the pesticide "Gammexane" [8]. In 1969, Hoshizaki et al. described the development of a leukemia following prolonged exposure to the pesticide hexachlorocyclohexane (HCH, BHC) and pp'dichlorodiphenyltrichloroethane [4]. Nowakowski et al. published a study in 1971 which suggested that the pesticide "Tetra-3" was a likely leukemogenic agent [13]. Finally,

experimental studies performed by Kemeny and Trajan, in which mice of the strain Balb/c were given very small doses of DDT, revealed, among other things, that there was a seven-fold increase in the frequency of neoplastic and leukemic changes in the fourth and fifth generations (up to 8.9%), compared to 1.2% in the control group (i.e. those not given DDT) [14].

Municipal and industrial sewage constitutes an enormous source of danger of degradation and contamination of the water environment in general, and drinking water in particular. It is enough to repeat Koczwanska's statement that "until 1974, there were 13,350 plants in Poland disposing sewage, only half of which were equipped with purification facilities - and that those facilities, for the most part, were not the best; only 1700 had received legal permission to dispose sewage into the water [11]. In effect, therefore, only the purification facilities of these 1700 plants had the capacity to ensure adequate protection against water pollution [11]."

The present author believes that these few examples are sufficient to illustrate emphatically and concretely the health hazards of polluting water with pesticides and other chemical compounds. Not only can water act a source and reservoir of danger; it can also function as a leacher of pesticides and other chemical compounds out of the soil environment, as well as a carrier of these substances in

man's natural environment, and in the various links of his trophic chain.

The current tendency towards an increase in the morbidity rate of certain diseases, especially cariovascular and neoplastic diseases, may be an expression not only of changes in the mineral composition of water (especially deficiencies of magnesium, selenium, etc.), but also the result of the effect on the human body of pesticides or other chemical substances which pollute the water, such as nitrosoamines, their parent substances (nitrites and nitrates), or "aflatoxins" - metabolites of the so-called imperfect fungi (Fungi imperfecti).

It is well known that under certain circumstances, 199
for example, in the presence of special varieties of bacteria in soil or the alkaline salts contained in human gastric juices, nitrites and nitrates can become parent substances for the synthesis of nitrosoamines (very powerful carcinogenic compounds which are especially active in the absence of so-called antioxidants such as selenium, vitamin E, etc.). It has also been noted that oxytetracyclines can change into various carcinogenic nitrosoamines in the presence in drinking water of nitrites and nitrates.

Of course, it would be an oversimplification to state that an excess or deficiency of some mineral element in water or food, or that the contamination of drinking water with some chemical compound will necessarily be reflected,

in simple linear fashion, in the level of that mineral or compound in the body, or that it will immediately cause some specific disease. Various other adaptational and regulatory mechanisms also come into play which, to a certain degree, may correct or neutralize these disturbances.

Nevertheless, those responsible for guaranteeing the supply of drinking water and maintaining health and sanitary control should be aware of the fact that degradation (understood as a change in natural mineral composition of water) and contamination of water may directly or indirectly result in changes in the body, and are most likely responsible for the increase in the incidence of so-called "diseases of modern civilization." The brief discussion and examples presented above suggest a number of medical recommendations regarding human drinking water.

1. The water environment is that componenet of man's natural environment to which he is most closely bound through the various links in his trophic chain; it should therefore be monitored and kept under special sanitary control for the good of human society.

2. The ionogram of bioelements in the human body, which determines its chemical composition, is in constant interaction with the level of those elements in the natural environment (water, soil), and for this reason should be monitored in drinking water as a factor affecting to human health.

3. All foreign chemical substances in drinking water (eg. detergents, pesticides, industrial wastes, etc.) should be eliminated, even though their unfavourable influences or pathogenic effects may not yet be sufficiently established.

4. All substances with long "half-lives" must be eliminated from man's natural environment because of the danger of cummulation and later consequences of prolonged activity.

5. As parent substances of carcinogenic nitrosoamines, nitrites and nitrates must be eliminated from drinking water; likewise organic mercury compounds, as mutagenic, teratogenic and most likely also leukemogenic agents, must also be eliminated.

6. Water should be enriched with antioxydants (eg. selenium) and elements which "protect" the human chromosomal system (magnesium).

7. The so-called hardness of water should not be deliberately decreased; on the contrary, it should even be increased.

8. The level of iron in drinking water should not be limited.

9. In the light of the ever-increasing chemicalization of the environment, especially the rural environment, it is essential to introduce as quickly as possible routine, periodic tests of well and surface water for the presence of pesticides, nitrites, nitrates and various organic Hg compounds.

10. Substantiated grounds exist for increasing the sanitary and toxicological control of drinking water as a rational method of preventing certain "diseases of civilization."

11. Natural protective areas around watersheds should be increased as much as possible, especially in foothill and mountain regions where the flow of surface water is significantly more extensive than in flat areas.

12. At the same time, a synchronous system of coordinating the control and monitoring of water intakes and drinking water distribution systems should be introduced; water should also be controlled at consumption points (not only at intakes), and an information bank should be set up.

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K. Janicki

DEGRADATION AND CONTAMINATION OF THE WATER ENVIRONMENT AS A THREAT TO HUMEN HEALTH

Summary

Water is a component of the natural environment of man, with which the latter is most closely and permanently associated. Alterations in its mineral content, such as magnesium, selenium and iron deficiency, as well as different biological and chemical contaminations (e.g. with pesticides, nitrosoamines, aphlatoxins) can be regarded as the manifestation of the character and intensity of changes occurring in the environment that surrounds man. Being one the trophic links of the human organism, water can directly or indirectly — influence its biochemical composition and the course of various biochemical reactions.

The excess or deficiency of the bioelements, i.e. elements essential for the human health, can exert a harmful effect on the human organism and induce directly or indirectly — particular diseases. In this respect the contamination of water (e.g. with various pesticides, nitrosoamines or their precursors such as nitrites or nitrates, aphlatoxins or other toxic metabolites produced by the imperfect fungi) is also not without importance.

The paper contains a review of more important publications and author's own observations devoted to this subject. It lead to a conclusion that the observed trend towards the increase in the frequency of some diseases, especially disorders of the cardiovascular system, hypoplastic or aplastic lesions of the hemopoietic system and different neoplastic proliferative diseases including leukemias might result from both, degradation of the mineral composition of water and its contamination with different toxic substances.

Consequently, the author presents the sanitary and medical requirements concerned with the drinkable water which seem to be necessary to consider in the prevention of many diseases of the contemporary civilization.